Conduction properties of graphene as a function of ion irradiation and acid treatment

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Materials research has reached impressively and exciting levels with the discovery of graphene. The modification and functionalization of graphene has proved to influence the electrical properties. This strategy is important during the pursuit of a completely tunable material when it comes to physical and electrical properties.

From first-principle simulations of the conductivity of graphene sheets, it has been shown that the insertion of defects in the graphene sheets leads to an increase of the conductivity with more than one order of magnitude [1]. To study this result experimentally, We have introduced defects in the graphene lattices by chemical and physical means, where we have studies of the change in conductivity of graphene with induction of defects.

In the case of acid treatment, graphene-like carbon nanosheets [ref to Jafri, J Phys D] were electrically characterized individually in a focused ion beam / scanning electron microscope (FIB/SEM). This results from this characterization showed that the conductivity increase roughly 50 times upon acid treatment of the nanosheets. This corresponds well to calculations which have showed that a so called metallicity appears around defects (divacancies) in the lattice and this lead to an increased conductivity.

In the case of ion irradiated graphene, electron beam lithography was used for contacting the graphene flakes. A voltage was applied across the contacted flakes giving rise to a current (in the order of nA) which was monitored with respect to time during the ion irradiation. A contacted graphene flake was irradiated with 30 keV Ga^{+} ions inside the FIB/SEM, see figure 1. The measured resistivity of the flake increased upon irradiation which is most likely related to the damage (sputtering) of carbon atoms as well as redeposition of the silicon dioxide substrate onto the graphene. The irradiation of 2 MeV protons on contacted graphene resulted in an decreased resistance by two to three times, see figure 2. The red areas and the numbers shows the irradiation periods. The blue areas are just relaxation time. The observed change in resistance is most likely due to charging of the substrate which will act as a gating effect on the measurement.

References

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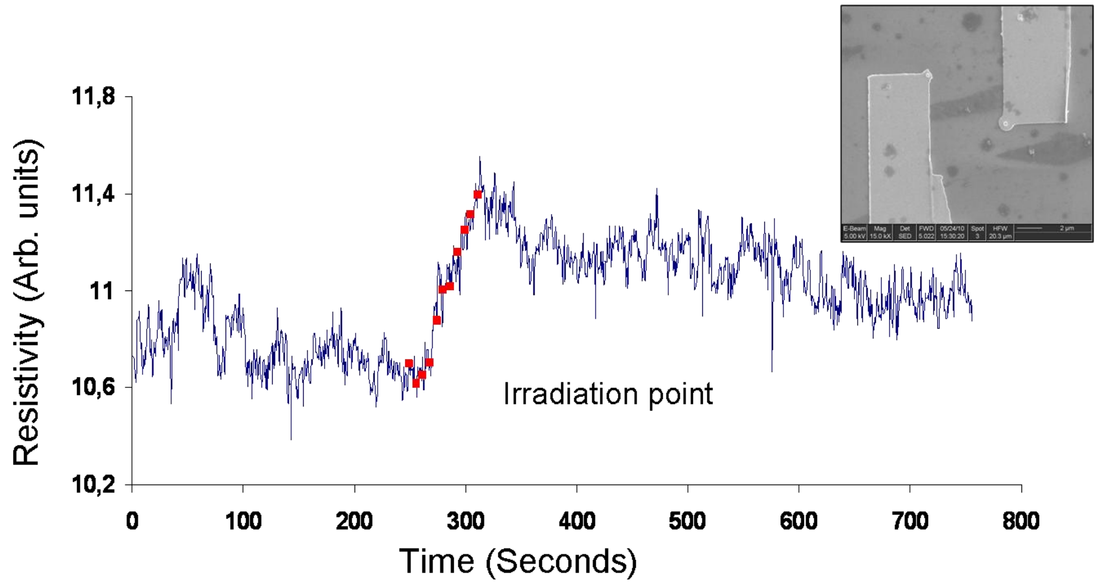

Figure 1. Measured resistivity during irradiation with 30 keV Ga^+ ions in the FIB/SEM. The inset to the right is a scanning electron image of the contacted graphene flake.

Figures

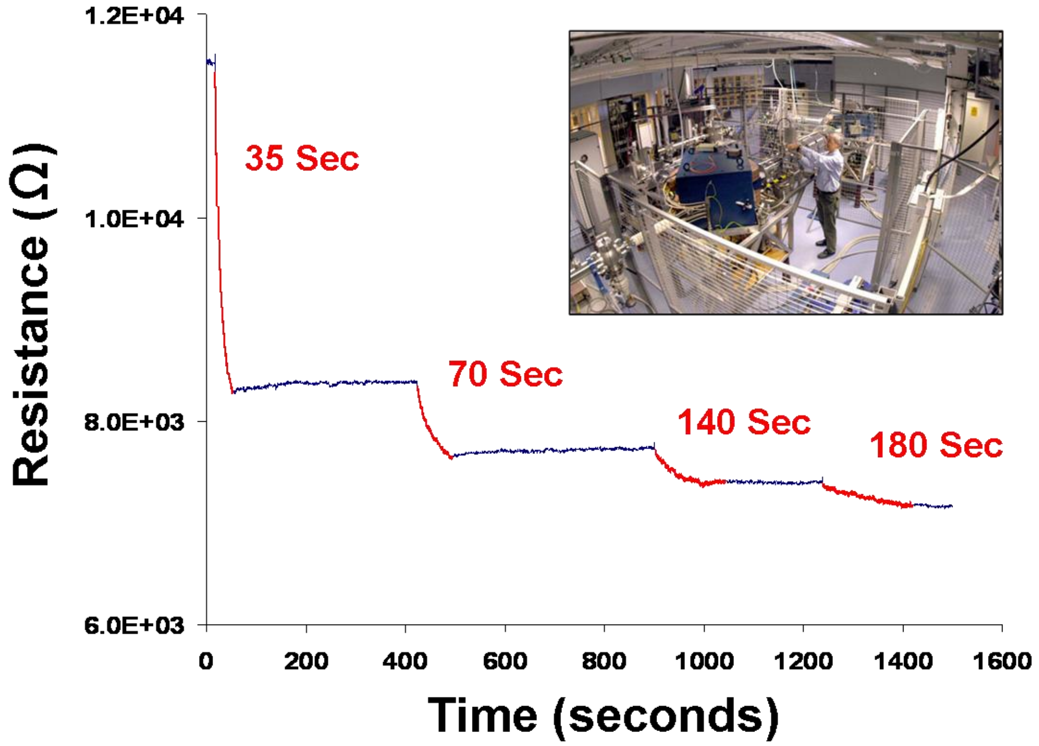

Figure 2. Measured resistance during irradiation with 2 MeV protons with a current of 40 nA/cm^2. The (red) time indications shows the periods of irradiation. The photograph shows a part of the Tandem accelerator at the Angstrom laboratory, used for this experiment.